

Beta-Neutrino Correlation in Laser Trapped ^{21}Na

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We have improved upon our previous measurement of the beta-neutrino correlation using magneto-optically trapped ^{21}Na atoms as our source. The beta decay rate (Γ) for an unpolarized nucleus is given by $\Gamma \propto 1 + a (\vec{p}_e \cdot \vec{p}_\nu / E_e E_\nu)$, where \vec{p}_e and \vec{p}_ν are the beta and neutrino momenta [1]. The neutrino momentum can be inferred from the momentum of the recoil nucleus. In the Standard Model, the beta-neutrino correlation coefficient, a , is calculated to be 0.558(3) for the mirror decay $^{21}\text{Na} \rightarrow ^{21}\text{Ne} + \beta^+ + \nu$ [2]. A precise measurement of a can limit the existence of scalar or tensor currents from higher mass weak bosons present in some extensions to the Standard Model.

We produce ^{21}Na ($T_{1/2} = 22.5$ s) on-line at the 88" Cyclotron by bombarding a heated magnesium oxide target with 2 μA of 25 MeV protons. The ^{21}Na atoms are slowed and trapped with a combination of laser and magnetic fields and brought nearly to rest in a small (FWHM < 1 mm) trap located between beta and recoil ion microchannel plate (MCP) detectors.

The precision of our previous measurement was limited to $\sim 5\%$ by beta detector triggers from scattered positrons and annihilation γ -rays. To suppress this effect, we have installed a heavy metal tipped collimator in front of the beta detector to reduce its field-of-view to a small region where the trap rests. Our previous beta detector, which had consisted of just a thick piece of plastic scintillator, was replaced by a ΔE -E telescope consisting of 1 mm and 15 mm thick pieces of plastic scintillator connected to separate photomultiplier tubes. The new detector was calibrated using a variety of radioactive sources such as $^{90}\text{Sr}/^{90}\text{Y}$, ^{207}Bi , ^{68}Ge , ^{14}C , and ^{99}Tc . A beta energy cut above 400 keV retains $\sim 88\%$ of the spectrum and limits the uncertainty in a resulting from the beta detector calibration to $< 0.5\%$.

The beta-neutrino correlation is determined by the time-of-flight (TOF) spectrum of the daughter ^{21}Ne ions in the presence of a drift electric field. Accurately determining this field is crucial to the measurement. A large aluminum ring was added in front of the MCP to simplify the modeling of the electrodes. Using the TOF of the ions as a measure of the electric field (after the distance between the trap and MCP was determined by the TOF of the neutral neon), the calculated electric field was consistent with the data to better than 0.1%. This level of agreement leads to an uncertainty in a of less than 0.5%.

In August of 2001, over 500,000 beta-ion coincidences were recorded (shown in Figure 1), resulting in a 0.75% statistical uncertainty. However, an unexpected variation in the detection efficiency (DE) over the face of the MCP was discovered and introduced a systematic shift in a of $\sim 2\%$. Using a low intensity beam of $^{20}\text{Ne}^+$ from the IRIS ECR at the 88" Cyclotron we have begun working on determining the spatial response of the MCP to keV-energy ions. If the DE is understood, the total experimental uncertainty attainable should be $\sim 1\%$.

Footnotes and References

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2. O. Naviliat-Cuncic, *et al.*, J. Phys. G **17**, 919 (1991).

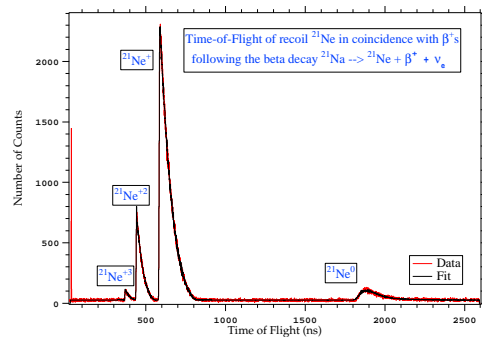


Figure 1. Time of flight spectrum with a Monte Carlo fit.